For which, this conſideration of the *Common Center of Gravity of the Earth and Moon*, is ſo proper a remedy (eſpecially if it ſhall be found preciſely to anſwer thoſe *Phænomena*, which I have not Examined, but am very apt to believe) that it is ſo far from being, with me, an Objection againſt it, that it is one of the reaſons, which make me inclinable to introduce it.

I muſt before I leave this, add one Conſideration more, That if we ſhall upon theſe Conſiderations think it reaſonable, thus to conſider the *Common Center of Gravity of the Earth and Moon*; it may as well be thought reaſonable, that the like Conſideration ſhould be had of *Jupiter* and his four *Satellites*, which according to the Complication of their ſeveral motions, will ſomewhat change the poſition of *Jupiter*, as to that *Common center of Gravity* of all theſe Bodies; which yet, becauſe of their ſmallneſs, may chance to be ſo little, as that, at this diſtance, the change of this apparent place may not be diſcernable. And what is ſaid of *Jupiter*, is in the like manner to be underſtood of *Saturne* and his *Satelles*, diſcovered by *Hugenius*: For all theſe *Satellites* are to their *Principals*, as ſo many Moons to the Earth. And I do very well remember, in the Letters forecited, Mr. *Horrocks* expreſſeth ſome ſuch little inequalities in *Saturnes* motion, of which he could not imagine what account to give, as if (to uſe his Expreſſion) this crabbed *Old Saturn* had deſpiſed his *Youth*. Which, for ought I know, might well enough have been accounted for, if at that time the *Satelles* of *Saturn* had been diſcovered, and that Mr. *Horrocks* had thought of ſuch a motion as the *Common Center of Gravity* of *Saturn* and his *Companion*, to be conſiderable, as to the guiding of his motion.

You have now, in obedience to your Commands, an Account of my thoughts, as to this matter, though yet immature and unpoliſhed: What uſe you will pleaſe to make of them, I ſhall leave to your prudence, &c.

An APPENDIX, *written by way of Letter to the* Publiſher; *Being an Anſwer to ſome Objections, made by ſeveral Perſons, to the precedent Diſcourſe.*

I Received yours; and am very well contented, that *objections* be made againſt my *Hypotheſis* concerning *Tydes*: being pro-

propoſed but as a conjecture to be examined; and, upon that Examination, rectified, if there be occaſion; or rejected, if it will not hold water.

1. To the firſt objection of thoſe you mention; *That it appears not how two Bodies, that have no tye, can have one common Center of Gravity:* that is (for ſo I underſtand the intendment of the objection) can act or be acted in the ſame manner, as if they were connected: I ſhall onely anſwer, that it is harder to ſhew *How* they have, than *That* they have it. That the Load-ſtone and Iron have ſomewhat equivalent to a Tye; though we ſee it not, yet by the effects we know. And it would be eaſy to ſhew, that two Load-ſtones, at once applyed, in different poſitions, to the ſame Needle, at ſome convenient diſtance; will draw it, not to point directly to either of them, but to ſome point between both; which point is, as to thoſe two, the *common Center of Attraction;* and it is the ſame, as if ſome *one* Load-ſtone were in that point. Yet have theſe two Load ſtones no connexion or tye, though a *Common Center of Virtue* according to which they joyntly act. And as to the preſent caſe, *How* the Earth and Moon are connected; I will not now undertake to ſhew (nor is it neceſſary to my purpoſe;) but, That there is ſomewhat, that doth connect them, (as much as what connects the Load-ſtone, and the Iron, which it draws,) is paſt doubt to thoſe, who allow them to be carryed about by the Sun, as one Aggregate or Body, whoſe parts keep a reſpective poſition to one another: Like as *Jupiter* with his *four Satellites*, and *Saturn* with his *one.* Some Tye there is, that makes thoſe *Satellites* attend their *Lords*, and move in a Body; though we do not *See* that Tye, nor *Hear* the Words of Command. And ſo here.

2. To the ſecond objection; *That, at Chatham and in the Thames, the Annual Spring-tydes, happen about the Æquinoxes; not (as this Hypotheſis doth ſuppoſe elſwhere to have been obſerved) about the begining of February and November.* If their meaning be, that Annual High Tydes, do then happen, and then onely: If this prove true, it will eaſe me of half my work. For it is then eaſily anſwered, that it depends upon the *Obliquity of the Zodiack*; the parts of the Æquinoctial anſwering to equal parts of the

Zodiack,

Zodiack, being neer the Solſtitial points greateſt, and near the Æquinoctial points leaſt of all. But beſide this *Annual Viciſſitude of the Æquinoxes*, not to ſay, of the 4. Cardinal Points (which my Hypotheſis doth allow and aſſert;) I believe it will be found, that there is *another Annual viciſſitude* anſwering to the Suns *Apogæum* and *Perigæum*. And that the greateſt Tydes of all, will be found to be upon a reſult of theſe two cauſes Co-operating: which (as doth the Inequality of Natural dayes, depending on theſe ſame cauſes) will light nearer the times, I mention. To what is ſaid to be obſerved at *Chatham* and in the *Thames*, contrary to that I allege as obſerved in *Rumney marſh*: I muſt at preſent ἐπέχειν, and refer to a *melius inquirendum*. If thoſe who object this contrary obſervation, ſhall, after this notice, find, upon new Obſervations heedfully taken, that the *Spring-tydes* in *February* and *November*, are not ſo high, as thoſe in *March* and *September*; I ſhall then think the objection very conſiderable. But I do very well remember, that I have ſeen in *November*, very high Tydes at *London*, as well as in *Rumney Marſh*. And, the time is not yet ſo far paſt, but that it may be remembered (by your ſelf or others then in *London*) whether in *November* laſt when the Tydes were ſo high at *Dover*, at *Deal*, at *Margate*, and all along the Coaſt from thence to *Rumney Marſh*, as to do in ſome of thoſe places much hurt, (and, in *Holland*, much more;) whether, I ſay, there were not alſo at the ſame time, at *London*, (upon the *Thames*) very high Tydes. But a good *Diary* of the Height and time both of High-water, and Low-water, for a year or two together, even at *Chatham*, or *Greenwich*; but rather at ſome place in the *open* Sea, or at the *Lands end* in *Cornwal*, or on the *Weſt parts of Ireland*; or at St. *Hellens*, or the *Bermodas*, &c. would do more to the reſolving of this point, than any verbal diſcourſe without it.

3. To the third Objection, *That ſuppoſing the Earth and Moon to move about a Common center of gravity; if that the higheſt Tydes be at the New-moon, when the moon being neareſt to the Sun, the Earth is fartheſt from it, and its compound motion at the ſwifteſt; and that the Tydes abate as the Earth approacheth nearer, till it comes into the ſuppoſed Circle of her Annual motion: It may be demanded, why do they not ſtill abate as the Earth comes yet nearer to the Sun and the*

ſwiftneſſe

ſwiftneſſe of its compound motion ſtill ſlackens? And ſo, why have we not Spring tides at the New Moon (when the motion is ſwifteſt) and Neap-tides at Full Moon (when the motion is ſloweſt) but Spring tides at both? The anſwer (if obſerved) is already given in my *Hypotheſis* it ſelf. Becauſe the effect is indifferently to follow, either upon a ſuddain Acceleration, or a ſuddain Retardation. (Like as a looſe thing, lying on a moving body; if the body be thruſt ſuddainly forward, that looſe thing is caſt back, or rather left behind, not having yet obtained an equal *impetus* with that of the body, on which it lyes; but if ſtopped, or notably retarded, that looſe incumbent is thrown forward, by its formerly contracted *impetus* not yet qualified or accomodated to the ſlowneſs of the Body, on which it lyes.) Now both of theſe happening, the one at the New Moon, the other at the Full Moon, do cauſe high Tides at both.

4. To the fourth Objection, *That the higheſt Tydes are not at all places, about the New Moon and Full Moon; and particularly, that, in ſome places of the Eaſt Indies, the Higheſt Tydes are at the Quadratures*: I muſt firſt anſwer in *general*; That as to the particular varieties of Tydes in ſeveral parts of the World, I cannot pretend to give a ſatisfactory account, for want of a competent Hiſtory of Tydes, *&c.* Becauſe (as is intimated in what I wrote in the *general*) the various poſitions of Chanels, Bays, Promontories, Gulfs, Shallows, Currents, Trade-winds, *&c.* muſt needs make an innumerable variety of Accidents in particular places, of which no ſatisfactory account is to be given from the general *Hypotheſis* (though never ſo true) without a due conſideration of all thoſe. Which is a task too great for me to undertake, being ſo ill furniſhed with materials for it. And then as to the particular inſtance of ſome places in the *Eaſt Indies*, where the higheſt Tydes are at the *Quadratures*: I ſuppoſe, it may be chiefly intended of thoſe about *Cambaia*, and *Pegu*. At which places, beſide that they are ſituate at the inmoſt parts of Vaſt Bayes, or Gulfs (as they are called) they have alſo vaſt In-draughts of ſome hundred Miles within Land; which when the Tydes are out, do lye (in a manner) quite dry: And may therefore very well be ſuppoſed to participate the effect of the Menſtrual Tydes many dayes after the

cauſe of them happens in the open Sea, upon a like ground as in Straights and narrow Channels the Diurnall Tydes happen ſome hours later than in the Ocean. And a like account muſt be given of particular accidents in other places, from the particular ſituation of thoſe places, as *Bays*, *Chanels*, *Currents*, &c.

5. To the 5. Objection, *That the Spring-Tydes happen not, with us, juſt at the Full and Change, but two or three daies after.* I ſhould with the more confidence attempt an Anſwer, were I certain, whether it be ſo in the *Open* Seas, or onely in our Channels. For the Anſwers will not be the ſame in both caſes. If onely in our Channels, where the Tydes find a large in-draught; but not in the Open Seas: we muſt ſeek the reaſon of it from the particular poſition of theſe places. But if it be ſo generally in the wide Open Seas: We muſt then ſeek a reaſon of it from the general Hypotheſis. And, till I know the matter of Fact, I know not well, which to offer at; leſt whilſt I attempt to ſalve one, I ſhould fall foul of the other. I know that Marriners uſe to ſpeak of Spring-Tydes at the New and Full of the Moon; though I have ſtill had a ſuſpition that it might be ſome daies after, as well in the open Seas, as in our narrower Channels; (and therefore I have choſen to ſay, in my Papers, *About* the New and Full, rather than *At* the New and Full; and even when I do ſay *At*, I intend it in that laxer ſenſe in which I ſuppoſe the Marriners are to be underſtood; for *Neer* that time:) Of which ſuſpition you will find ſome intimations even in my firſt Papers: But this though I can admit; yet, becauſe I was not ſure of it, I durſt not build upon it. The truth is, the Flux and Reflux of water in a veſſel, by reaſon of the jogging of it; though it follow thereupon; yet is, for the moſt part, diſcernable ſome time after. For there muſt, upon that jog, be ſome time for Motion, before the Accumulation can have made a Tyde. And ſo I do not know but that we muſt allow it in all the Periods. For as the *menſtrual* High Tyde, is not (at leaſt with us) till ſome Daies after the Full and Change; ſo is the *Diurnal* High water, about as many Hours after the Moons comming to South; (I mean, At Sea: for in Chanels it varies to all Hours, according as they are neerer or further from the open Sea:) And the *Annual* High-Tydes of *November* and *February*; ſomewhat later than

(what I conjecture to be from the ſame cauſes) the greateſt Inequalities of the natural Days, happening in *January* and *October*. But this though I can admit, yet (till I am ſure of the matter of Fact) I do not build upon. And ſince it hath hitherto been the cuſtome to ſpeak with that laxneſs of expreſſion; aſſigning the times of New-moon, Full-moon, and Quadratures, with the Moons comming to South, for, what is neer thoſe times: I did not think my ſelf obliged in my conjectural Hypotheſis (while it is yet but a *Candidate*) to ſpeak more nicely. If the Hypotheſis for the maine of it be found Rational; the Niceties of it are to be adjuſted, in time, from particular Obſervation.

Having thus given you ſome Anſwers to the Objections you ſignifie to have been made by ſeveral perſons to my Hypotheſis, and that in the ſame order your Paper preſents them to me: I ſhall next give you ſome account of the two *Books*, which you adviſed me to conſult; ſo far as ſeems neceſſary to this buſineſs: Which, upon your intimation, I have ſince peruſed, though before I had not.

And firſt, as to that of *Iſaac Voſſius*, *De motu Marium & Ventorum*; Though I do not concur with him in his Hypotheſis; That all the *Great motions of the Seas*, &c. ſhould ariſe onely from *ſo ſmall a warming of the water* as to raiſe it (where moſt of all) *not a Foot* in perpendicular, (as in his 12*th* Chapter;) Or that there is no other connexion between the Moons motion, and the Tydes *menſtrual* period, than a *caſual Synchroniſm* (which ſeems to be the doctrine of his 16*th* and 18*th* Chapters;) Beſide many other things in his Philoſophy, which I cannot allow: Yet I am well enough pleaſed with what is Hiſtorical in it, of the matter of Fact: Eſpecially if I may be ſecure, that he is therein accurate and candid, not wreſting the *Phænomena* to his own purpoſe. But I find nothing in it, which doth induce me to vary from my Hypotheſis. For, granting his Hiſtoricals to be all true; the account of the conſtant Current of the Sea Weſtward, and of the conſtant Eaſtern Blaſts, &c. within the *Tropicks*, is much more plauſibly, and (I ſuppoſe) truly rendered by *Galilæo* long ſince, from the Earths *Diurnal* motion: (which, neare the *Æquator*, deſcribing a greater Circle, than nearer the

Poles,

Poles, makes the Current to be there more conſpicuous and ſwift, and, conſequently, the Eddy, or recurrent motion, nearer the Poles, where this is, more remiſs:) than can eaſily be rendered by ſo ſmall a Tumor, as he ſuppoſeth. Not to adde; that his account of the Progreſſive motion, which he fanſieth to follow upon this Tumefaction, and by Acceleration to grow to ſo great a height near the Shoar (as in Chap. 13. and 14.) is a Notion, which ſeems to me too extravagant to be ſalved by any laws of *Staticks*. And that of the Moons motion onely Synchronizing with the Tydes, caſually, without any *Phyſical* connexion; I can very hardly aſſent to. For it can hardly be imagined, that any ſuch conſtant *Synchroniſme* ſhould be in Nature; but where, either the one is the cauſe of the other, or both depend upon ſome *Common* cauſe. And where we ſee ſo fair a foundation for a *Phyſical* connection. I am not prone to aſcribe it to an Independent Synchroniſm. In ſum; His Hiſtory doth well enough agree with my Hypotheſis; and I think, the Phænomena are much better ſalved by mine, than his.

And then as to *Gaſſendus*, in his diſcourſe *De Æſtu Maris*; I find him, after the relating of many other Opinions concerning the Cauſe of it, inclining to that of *Galilæo*, aſcribing it to the Acceleration & Retardation of the Earths motion, compounded of the Annual and Diurnal; And moreover attempting to give an account of the *Menſtrual Periods* from the Earths carrying the Moon about it ſelf, as *Jupiter* doth his *Satellites*; which together with them is carryed about by the *Sun*, as one Aggregate; (and that the Earth with its Moon is to be ſuppoſed in like manner to be carried about by the Sun, as one Aggregate, cannot be reaſonably doubted, by thoſe who entertain the *Copernican Hypotheſis*, and do allow the ſame of *Jupiter* and his *Satellites*.) But though he would thus have the Earth and Moon looked upon as two parts of the ſame moved Aggregate, yet he doth ſtill ſuppoſe (as *Galilæo* had done before him) that the line of the Mean Motion of this Aggregate (or, as he calls, *motus æquabilis et veluti medius*) is deſcribed by the *Center* of the *Earth* (about which Center he ſuppoſeth both its own revolution to be made, and an Epicycle deſcribed by the Moons motion;) not by another Point, diſtinct from the Centers of both, about which, as the common Center of Gravity, as well that of the Earth, as that of the Moon, are to deſcribe ſeveral Epicycles. And, for that Reaſon fails of giving any clear account of this *Menſtrual* Period. (And in like manner, he propoſeth the Conſideration as well of the Earths *Aphelium* and *Perihelium*, as of the *Æquinoctial* and *Solſtitial* Points, in order to the finding a Reaſon of the *Annual* Viciſſitudes; but doth not fix upon any thing, in which himſelf can Acquieſce: And therefore leaves it *in medio* as he found it.)

It had been more agreeable to the Laws of *Staticks*, if he had, (as I do,) ſo conſidered the *Earth* and *Moon* as two parts of the ſame movable, (not ſo, as he doth, *aliam in Centro et ſequentem præciſe revolutionem axis, aliam remotius ac velut in circumferentia,* but,) ſo, as to make neither of them the Center, but both out of it, deſcribing Epicycles about it: Like as, when a long ſtick thrown in the Air, whoſe one end is heavyer than the other, is whirled about, ſo as that the End, which did firſt fly foremoſt, becomes hindmoſt; the proper line of motion of this whole Body is not that, which is deſcribed by either End, but that, which is deſcribed by a middle point between them; about which point each end, in whirling, deſcribes an Epicycle. And indeed, in the preſent caſe, it is not the Epicycle deſcribed by the Moon, but that, deſcribed by the Earth, which gives the *Menſtrual* Viciſſitudes of motion to the Water; which would, as to this, be the ſame, if the Earth ſo move, whether there were any Moon to move or not; nor would the Moons Motion, ſuppoſing the Earth to hold on its own courſe, any whit concern the motion of the Water.

But now, (after all our Phyſical, or Statical Conſiderations) the cleareſt Evidence for this Hypotheſis (if it can be had) will be from Celeſtial Obſervations. As for inſtance; (ſee *Fig*.5.) Suppoſing the Sun at S; the Earths place in its Annual Orb at T; and *Mars* (in oppoſition to the Sun, or near it) at M: From whence *Mars* ſhould appear in the Zodiack at γ, and will at Full moon be ſeen there to be; the Moon being at C and the Earth at c: (and the like at the New-moon.) But if the Moon be in the Firſt quarter at A, and the Earth at a; *Mars* will be ſeen, not at γ, but at α; too ſlow: And when the Moon is at B, and the Earth at b. *Mars* will be ſeen at β; yet too ſlow: till at the Full-moon, the Moon at C, the Earth at c, *Mars* will be ſeen at γ, its true place, as if the Earth were at T. But then, after the Full, the Moon at D, the Earth at d; *Mars* will be ſeen, not at γ, but at δ; too forward: and yet more, when the Moon (at the laſt Quarter) is at E, the Earth at e, and *Mars* ſeen at ε. If therefore *Mars* (when in oppoſition to the Sun) be found (all other allowances being made) ſomewhat too backward before the Full moon, and ſomewhat too forward after the Full-moon, (and moſt of all, at the Quadratures:) it will be the beſt confirmation of the Hypotheſis. (The like may be fitted to *Mars* in other poſitions, *mutatis mutandis*; and ſo for the other Planets.)

But this proof, is of like nature as that of the Parallaxis of the Earths Annual Orb to prove the Copernican Hypotheſis. If it can be obſerved, it proves the Affirmative; but if it cannot be obſerved, it doth not convince the Negative, but only proves that the Semidiameter of the Earths Epicycle is ſo ſmall as not to make any diſcernable Parallax. And indeed, I doubt, that will be the iſſue. For the Semidiameter of this Epicycle, being little more than the Semidiameter of the Earth it ſelf, or about $1\frac{1}{3}$ thereof (as is conjectured, in the *Hypotheſis*, from the Magnitudes and Diſtances of the Earth and Moon compared;) and there having not as yet been obſerved any diſcernable *Parallax* of *Mars*, even in his neereſt poſition to the Earth; it is very ſuſpicious, that here it may prove ſo too. And whether any of the other Planets will be more favourable in this point, I cannot ſay.

ANIMADVERSIONS

Of Dr. Wallis, *upon Mr.* Hobs's *late Book*, De Principiis & Ratiocinatione Geometrarum.

Theſe were communicated by way of Letter, written in *Oxford*, July 24. 1666. to an Acquaintance of the *Author*, as follows:

SInce I ſaw you laſt, I have read over Mr. *Hobs*'s Book *Contra Geometras* (or *De Principiis & Ratiocinatione Geometrarum*) which you then ſhewed me. A *New* Book of *Old* matter: Containing but a *Repetition* of what he had before told us, more than once; and which hath been Anſwered long agoe.

In which, though there be Faults enough to offer ample mat-